

Domestic Solar Panel Cleaning System

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Abstract In this research paper, a new way of approach to the solar panel cleaning system, a past researcher has proposed many ways to improve and classify the object and present it in an image. Solar panels play an important role in a clean energy future and no harmful emissions are released into the air when electricity is produced by solar panels. On continuous using of solar panels, a layer of accumulated dust particles is settled on the surface of solar panels or PV panels which affect the result of decreasing in efficiency by 50 %. By cleaning on regular intervals it decreases this soil loss. This paper analyses the research papers on cleaning system and proposed a solution to the solar cleaning system in the domestic region.

Keywords— Solar panels, Efficiency, Arduino circuit, 3D printer, Cleaning, Soil loss, Dust accumulation.

I. INTRODUCTION

Drawing lessons from ancient Indian history when five natural elements including Sun, Wind, Fire, Earth, and Water were known as life elements of the planet earth. [1] The solar power where the sun hits atmosphere is 10^{17} W, whereas the solar power on earth's surface is 10^{16} W. The total worldwide power demand of all needs of civilization is 10^{13} W. [2] therefore the sun gives us 1000 times more power than we need. As of this in 2009 India's first-ever commercial 2MW solar power plant is setup in Amritsar. [2] The Ministry of New and Renewable Energy has set a target of making 175 GW capacities of solar installations by March 2022.

India is among the leading countries having good Direct Normal Irradiance¹ (DNI), which depends on the geographic location, earth sun movement, tilt of Earth rotational axis and atmospheric attenuation due to suspended particles.

India is estimated to have huge potential for solar energy which is about 5000 trillion kWh per year. Now the main un-highlighted problem is that on continuous using of solar panels, a layer of accumulated unwanted dust particles is settled on the surface of solar panels or PV panels which affect the result of decreasing efficiency of solar. (Figure 1)

Now the main highlighted problem is that on continuous using of solar panels, a layer of accumulated unwanted dust particles is settled on the surface of solar panels or PV panels which affect the result of decreasing efficiency by 50 % or it may vary. At a large scale of projects, the cleaning system is working in a perfect independent hierarchy, but at the domestic sector all cleaning system hierarchy collapses.



Figure 1: Clean solar panel and dust accumulated solar panel.

¹ DNI is solar radiation that comes in a straight line from the direction of the sun at its current position in the sky.

² One such factor is soiling and the **loss of power** associated with such factor is known as soiling **loss**.

This accumulated dust is responsible for soil loss² on solar panels which decreases its efficiency of generation of solar energy. It has to be cleared on regular interval of time for better results.

Dust settlement for the most part depends on numerous components like compound properties, size, weight, shape, site, tilt point surface completion, stickiness, wind speed, etc. Dust exposure affects many parameters of SPV; so several attempts have been made to address this issue (Table 1).

Table 1. Factors affecting the reaction to dust

Parameters	Details
Frequency of dust settlement incidents	Generally a community is equipped to withstand an incident once a month, however, the community needs to prepare for repetitive incidents at frequencies of once or twice a week.
Amount of dust deposited	Dust deposition has an inverse relationship with distance of the dust source and is one of the major factors for determining the level of complaint.
Affected area of deposition	If the emissions upsurge, then there is a probability for larger area therefore will increase the probability of complaint.

Dust particles are very common in the atmosphere. In some places, it is found settled but at some it is not; for example in National Capital Region (NCR) due to Rajasthan the dust particles drifting towards NCR and causing a dip in the air quality of Delhi. And when it gets settled it may be also settled on solar panels or PV panels and according to studies the layer accumulated dust on the surfaces of solar panels or PV panels can come from many different sources and can have a major impact on electricity production. The efficiency of the solar panel can be reduced by up to 50% in a dusty environment, as this interferes with the amount of direct sunlight received to the PV array.[3] (Figure2)

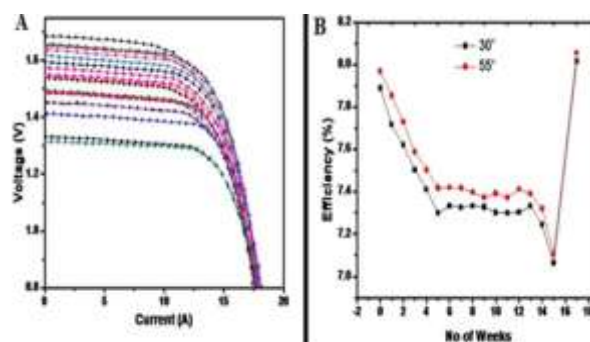


Figure 2. The efficiency of solar panel reduced by 50%.

The main cause of the reduction of solar cell power is the attenuation in transmittance of light due to the dust accumulation on the glass cover.

The dust accumulation process is very easy it starts first by a simple layer accumulation until it covers all the surface, then a second layer will deposit on top of it and so on. To calculate the scattered light efficiency, we suppose that the dust particles are spherical and are composed mainly of SiO₂³, thus the refractive index for the Silicon oxide as a function of the wavelength was used. [4]

When these particles are illuminated they will absorb and scatter the light, which will reduce the intensity of the light beam, this effect is known as the extinction efficiency that is governed by the ratio of the particle size to the wavelength of the incident light.

Cause of dust accumulation: There are two interdependent parameters that effect on the characterization of soiling accumulation on solar panels, the property of dust and the local environment. Dust property consists of size, components, shape, and weight. For example in Malaysia, the dust is acidic and can cause erosion to the surface of the panel. The local environment refers to the surroundings that the human activity has directly or indirectly created such as the built environment, types of vegetation, and weather conditions.

Furthermore, the surface is also a very important contributing factor in the soiling process. If the surface is not smooth,

³ Silicon is the second most abundant element in the crust of the earth after oxygen, with a mean content of 28.8 % (weight) and an occurrence that ranges from 0.52 to ~47 wt%.

and instead is rough, furry, sticky, and etc, it allows more soil to accumulate. The position of the panel which depends on the sunlight direction and wind is also important in the soiling process. The more horizontal the surface is, the more dust will be accumulated.[6]

Besides, the slow breeze also can result in dust accumulation whereas strong wind can clear the panel surface. However, airflow due to wind is able to affect the dust accumulation or dissipation at particular places of the solar panel. The airspeed and pressure are not constant over the solar panel surface. In the presence of wind, wherever the airspeed is higher, there is lower pressure which can result in less soil accumulation and vice-versa. Dust properties such as type, size, weight, and shape also play an important role in dust scattering. Describes different problems that results in soil accumulation on solar panels. [6]

It also shows some factors have correlation which shows by an error that needs to investigate by future study compares soil effect various locations around the world. It can be seen in the table that the majority of the studies are done in the USA and Asian countries. Technically, Dust reduces output power from PV between 2% to 50% in different areas. In Asian reign, most of the dust materials are sand and soil and also in African countries dust comes from the desert area that accumulates on the surface. (Figure 3)[6]

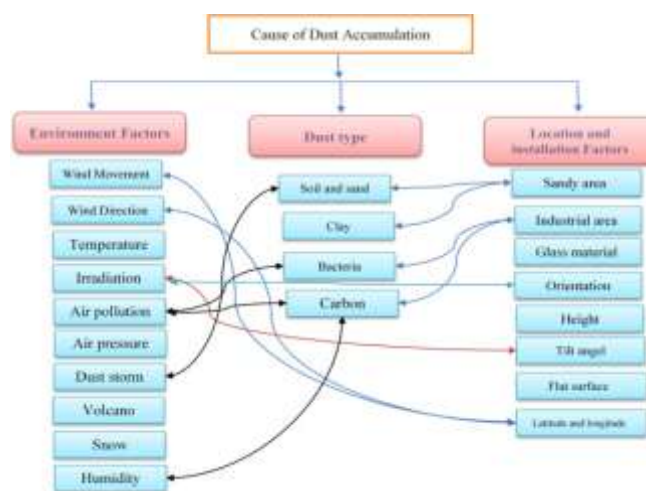


Figure3. Cause of dust accumulating on the surface of solar array.

II. METHODOLOGY

The principal objective of this work is to study the effect of dust and dirt on solar panels and study all aspects of a possible cleaning system which increases the efficiency of solar panels. We studied atleast 22+ research papers ,daily articles and attended the 13th edition of Renewable Energy India 2019 Expo[11] which helped us to expend our reserch at different stages.

Throughout our whole research, we read several papers from different sources some of the important points are given below.

Cleaning process is essential for longer life span and uninterrupted working of the solar panel with higher efficiency. The cleaning properties depend mainly on the type of dust in that region. The cleaning process of solar panel installed on the roof of the house, industry, desert areas are very difficult as dust particle does not allow the solar radiations to absorb in the panel properly. The cleaning methods of solar panel can be broadly classified into active methods and passive methods. [5] (Table2)

Table 2. Active method vs. Passive method

ACTIVE METHODS	PASSIVE METHODS
<ul style="list-style-type: none"> • Make use of power 	<ul style="list-style-type: none"> • Donot make use of power
Includes, <ul style="list-style-type: none"> • VACUUM SUCTION CLEANING • AUTOMATIC WIPER BASED CLEANING • ELECTROSTATIC PRECIPITATOR • CLEANING ROBOT • AIR BLOWING FROM AIR CONDITIONING SYSTEM 	Includes, <ul style="list-style-type: none"> • MANUAL CLEANING • SUPERHYDROPHOBIC COATING • SUPERHYDROPHILIC COATING • NATURAL METHOD

Passive methods leads to dependent on human but active methods leads to dependent on power at domestic sector of solar cleaning we see the possible vision of it.

The main objective of our team is that to give a simple and compact mechanism of cleaning system for domestic region.

Proposed cleaning system:

If you have a residential solar energy system installed, your solar panels are generally flat, tilted, and on your rooftop. How often do you clean your roof? Probably not often, most likely never. Why's that? I hear you saying "Isn't that what rain is for?" That's kind of the same logic for solar panels too. An Automatic Belt-Pulley drive system along with the length of solar panels which is controlled by arduino⁴ circuit and trigger the cleaning system of solar panels. As result it helps solar panels to regain their original efficiency to generate solar electricity for work. We make cleaning mechanism as much simple a we can, basically the idea of making this design comes from an FDM 3D printing mechanism it is so because 3D printer gives high accuracy

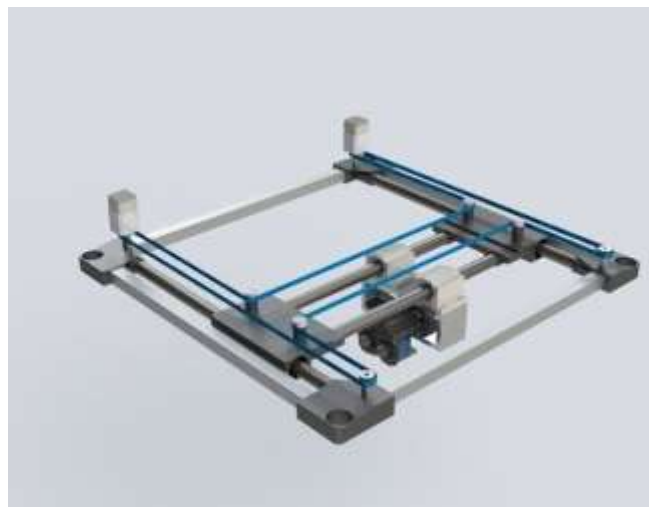


Figure 4. PID Controlled Arduino-Based Stabilizer

and precision in coordination to print the objects as they are designed to balance an inverted pendulum requires the accuracy and precision exhibited by the 3D printer, hence the stabilizer mechanism is built. (Figure4)

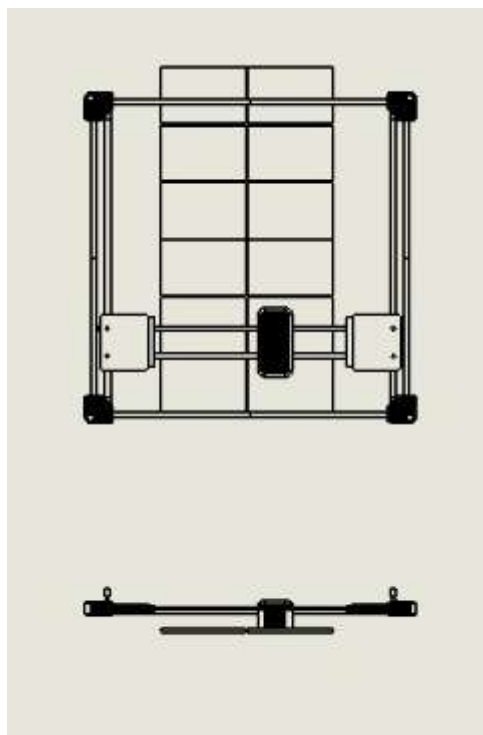
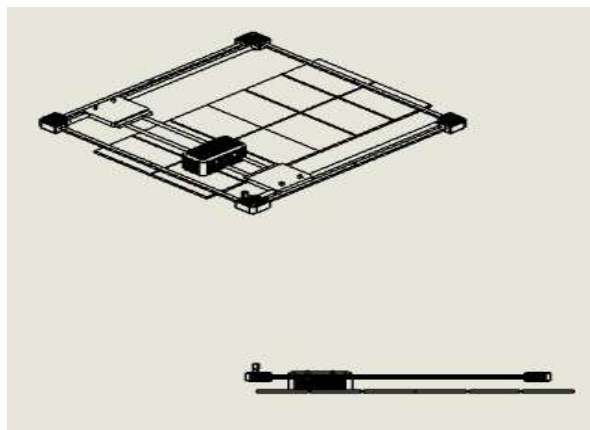
Essential parts of the mechanism (figure5):

1. **Supporting frame:** Frame provides strength to the model which makes the project capable of sustaining different weather conditions.
2. **Guide blocks:** Blocks provide path for the motion of the cleaning and also connects the cleaning block to the motor.
3. **Grooved belts:** Connects the mechanism and integrate the timing of the motion.
4. **Stepper motors:** Uses discrete steps in order to produce movement. Enables the mechanism to motion independently on the desired dimensions covering the entire space.
5. **Cleaning block:** The middle part of the mechanism which does the primary motion covers the X plane of the solar panels. The bottom surface has been integrated with micro-fiber cloth which is quite common in the cleaning of solar panels.

⁴Arduino consists of both a physical programmable **circuit** board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

Process

- Controller will be used to trigger the cleaning system by the user.
- Electric Connection consisting of Arduino circuit can be configured depending upon the requirement of the size of panels.
- The Arduino circuit will command the first motor that move at specific speed and to a desired position and second motor will guided belt and cleaning the panels.
- The block may contain a set of small water sprays to spread water over the panels and a viper (micro-fiber cloth) to clean the surface.
- Movement of blocks will be linear from end to end covering majority of surface of the rectangular/square shaped panels.

**Figure 5(a).** Top and front view**Figure5(b).** Isometric and side view

Conclusion and future perspective

As we can see deposition of dust (biological or chemical) leads to a decrease in the efficiency of solar panel which affects its performance. So cleaning of the solar panels is equally important also in this paper we have discussed different types of cleaning systems and methods that can be applied. Compared to other methods our system is the best and more importantly cost-effective. The system developed by us is to overcome the following problems faced after solar panel installation: reduced power due to dust accumulation, cost reduction for the overall cleaning of solar panel, manual labor for cleaning which has inevitable physical harms is avoided, reduced time for cleaning. By replacing conventional cleaning methods of the solar panel with the automation we can maintain the efficiency without affecting its performance.

Hence, periodically dust must be removed from the solar panel, in order to ensure the highest performance.

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